Fermilab

NuMI RAW Horn Flowmeter Panel

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The Flowmeter Panel is responsible for generating: 1) A Horn power supply permit and 2) A summation of RAW flow meter trips. The “Panel” hereto refers to the entire chassis assembly including the printed circuit board, front panel display and front panel I/O.

Flow meter contact status is represented by one of 16 bicolor LED’s located on the front panel display, yellow indicating a closed contact and red indicating open. Two additional LED’s indicate the status of the Horn PS Permit and of DC power.

Two rows of 11 headers allow connection to the flowmeter switches as well as external power and remote reset, permit and trip status

Flowmeter Panel I/O

Header	Description	Comments
JP1 – JP16	Flowmeter 1 through 16	1 contact pair
JP17 pin 1	/Remote_Reset	1 contact
JP17 pin 2	Optocoupler supply voltage	1 contact
JP18	/Trip	1 contact pair
JP19, JP20 pin1	24v return	1 contact
JP19, JP20 pin2	24 v input	1 contact
JP21	Permit	1 contact pair

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Permit

The Horn PS Permit represents a summation of up to 16 flow meter switch contacts.

One Form A relay provides two relay contacts; one for the actual permit to the front panel I/O and the other for the status LED on the front panel display. A closed relay indicates the permit is made up.

The 16-flowmeter switch inputs are grouped into two banks of 8 each. Each bank of 8 is wired in series through a cascade of 4, dual channel optoisolators. In each pair, the cathode of the first photodiode is wired to the anode of the second. The cathode of the second is wired to the anode of the photodiode in the next optoisolator and so on, thereby creating a series string of 8 optocouplers. The input to the string is 24vdc while the output is attached to the relay coil of 1 Form A relay. If a flowmeter switch is closed, its optoisolator is bypassed. With the switch open, the emitter of the optoisolator turns on, changing the corresponding LED indicator from closed to open status. All the switches must be closed for the relay coil to energize. Permit relays are not latched

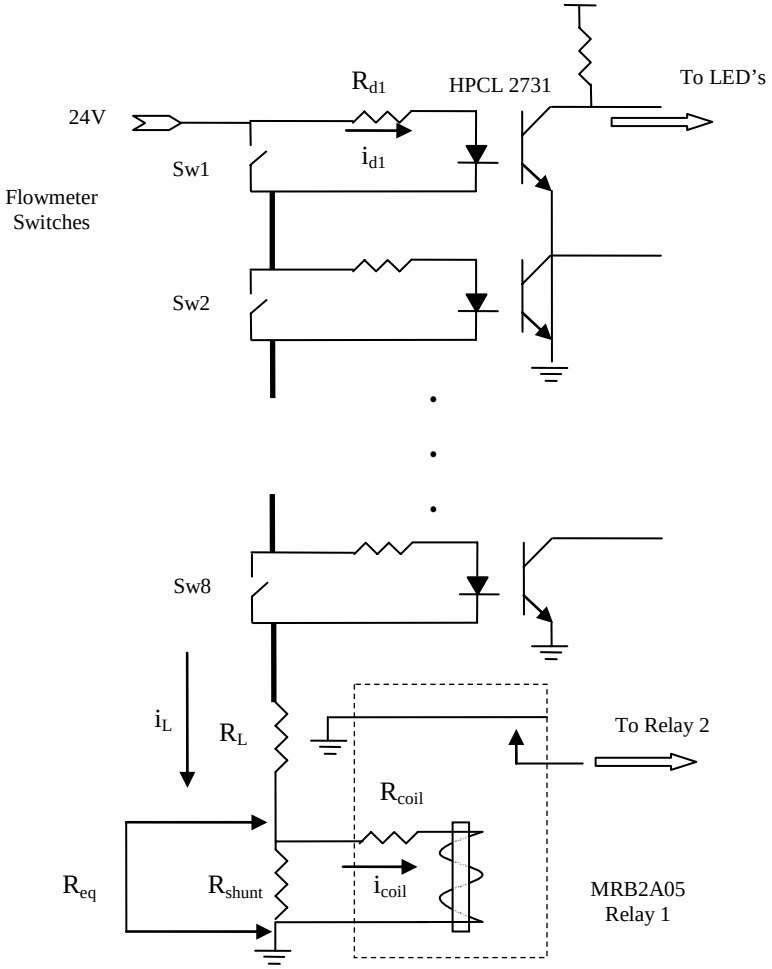

Figure 1

Flowmeter Relay

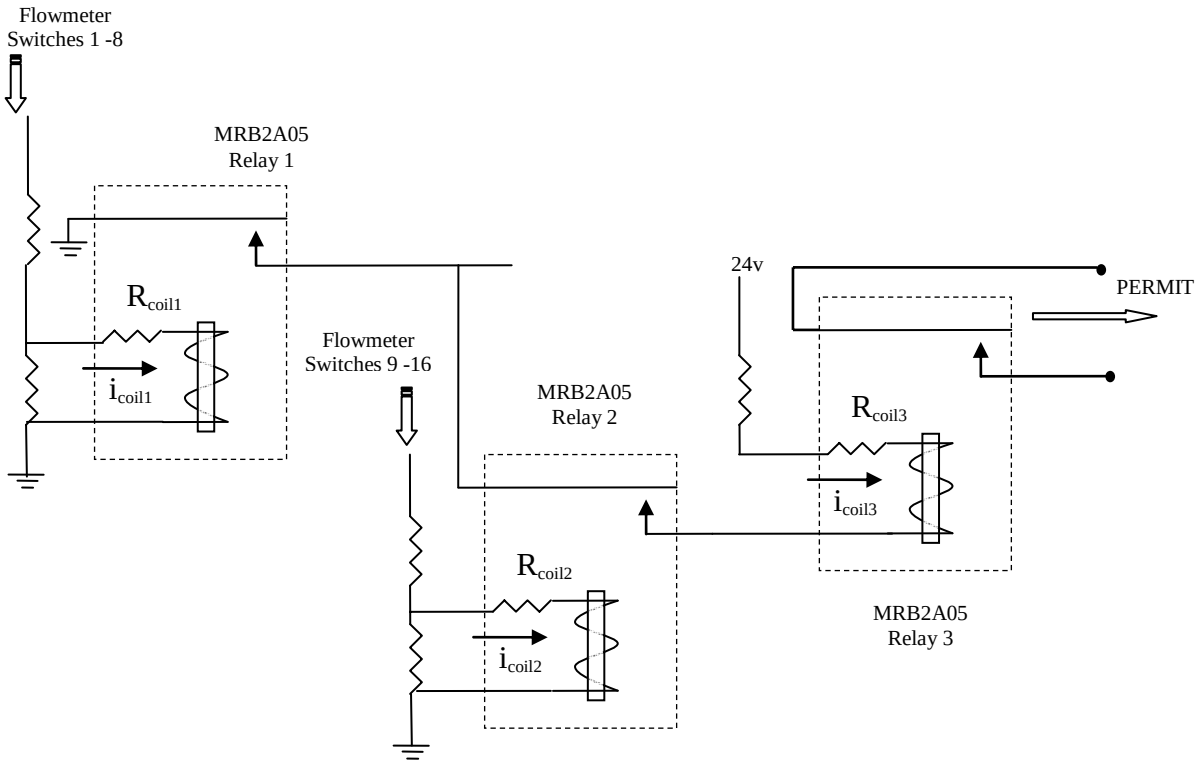

Figure 2
Flowmeter Permit Block Diagram

Operating characteristics for the devices:

HPCL 2731 detector	$I_{d\ min}$	$I_{d\ max}$	V_d
	0.5mA	60mA	1.45v @20mA 1.4v @ 8mA 1.3v @2mA 1.25v @0.5mA
MRB2A05 coil	I_{ON}	I_{OFF}	R_{coil}
	>20mA	<10mA	100ohms

With all switches closed, resistor values are chosen to allow the relay to operate. Choosing R_L = 392 ohms and *Rshunt* = 100 then Req = 100||200 = 50ohms.. With all switches closed:

$$i_L = \frac{24}{392+50} = 54.3mA$$

$$i_{coil} = \left(100 \diagup 200\right) * 54.4 = 27.1mA > I_{ON}$$

The relay must shut off when 1 or more switches are open. With one switch open, the current must fall below 10mA to shut off the relay. Choosing Ioff = 8mA, the minimum resistance of R_d to turn off the relay:

$$i_{coil} = 8\text{mA}$$

$$i_L = \frac{i_{coil}}{100/200}$$

$$i_L = \frac{24 - V_d}{R_d + R_L + R_{EQ}}$$

Substituting and solving for R_d:

$$R_{d\,\min} = \left(\frac{24 - V_d}{\frac{i_{coil}}{100 \diagup 200}} \right) - \left(R_L + R_{EQ}\right)$$

$$R_{d\,\min} = \frac{24 - 1.4}{0.008 \diagup \frac{100}{200}} - \left(392 + 50\right) = 970\text{ohms}$$

. With all the switches open, the current must still be high enough to turn on all the optocouplers and light the corresponding LED's. $R_{d\,max}$ must allow at least 0.5 mA with all the switches open. Choose $I_{d\,min}$ = 2.0mA:

$$R_{d\,\max} = \frac{24 - \left(8 * V_d\right)}{i_{d\,\min}}$$

$$R_{d\,\max} = \frac{24 - \left(8 * 1.3\right)}{2.0 * 10^{-3}} = 6.8\text{k}$$

Choose R_d = 1.2k and check:

1. One switch open:

$$i_L = i_d = \frac{24 - V_d}{R_d + R_L + R_{EQ}} = \frac{24 - 1.4}{1200 + 392 + 50} = 13.8mA$$

$$\text{and} \quad i_{d\min} < 13.8mA < i_{d\max}$$

$$i_{coil} = \left(100 \diagup 200\right) * 13.8 = 6.9mA < I_{OFF}$$

2. All switches open:

$$i_L = i_d = \frac{24 - (8 * V_d)}{(8 * R_d) + R_L + R_{EQ}} = \frac{24 - (8 * 1.3)}{(8 * 1200) + 392 + 50} = 1.4mA$$

$$i_{d\min} < 1.4mA < i_{d\max}$$

Trips

1 of 16 LED's on the front panel display represents the status of each flow meter contact. A closed contact displays a yellow LED; an open contact displays a red LED. A red LED indicates a "trip" for its corresponding flow meter contact.

Each trip is latched and will stay latched when its flow meter contact re-closes. One Form A, NO relay provides 1 relay contact as a TRIP output. Any trip will close the TRIP relay. All trips must be cleared for the TRIP relay to open. All trips are cleared simultaneously by either pressing the front panel Reset tact switch, or by a remote, active low TTL Reset from the rear panel.

Panel Test Results

	All switches closed		Sw 1 open, Sw 2-16 closed		Sw 1 closed Sw 2-16 open		All switches open	
	i_{d1}	i_{coil3}	i_{d1}	i_{coil3}	i_{d1}	i_{coil3}	i_{d1}	i_{coil3}
Panel #1								
Panel #2								
Panel #3								